Plus and Min

Enhancement to Transient

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Over one hundred years ago, Baron Jean Baptiste Fourier showed that any repeatable waveform that exists in the real world could be generated by adding up sine waves. Figure 1 is a simple waveform composed of two sine waves. Conversely, signals can be broken down into these same sine waves.

The traditional way of observing signals is to view them in the time domain. The time domain is a record of what happened to a parameter versus time. Figure 2a shows a three-dimensional graph of this addition of sine waves. The mutually orthogonal axes (axes at right angles to each other) are amplitude, time, and frequency. When you view this three-dimensional graph looking at amplitude versus time, you are in the time domain and you see the summation of the sine waves (Figure 2b).

If you view the graph looking at amplitude versus frequency, you are in the frequency domain and get a totally different picture (Figure 2c). Here we have axes of amplitude versus frequency, the frequency domain view, or what is commonly called a Spectrum plot. Every sine wave in the frequency domain appears as a vertical line, which can be thought of as the end view of the sine wave. Its height represents its amplitude and its position represents its frequency.

A Fast Fourier Transform (FFT) is a mathematical algorithm which transforms data from the time domain to the frequency domain, a way to break a signal into its frequency components. Today's microprocessors permit you to incorporate all the computing power needed by an FFT in a small instrument package. FFTs use complex numbers for their inputs, computations and outputs. Complex numbers are composed of a direct (or real) part and a quadrature (or imaginary) part (Figure 3).

One interesting, and often ignored, characteristic of FFTs is that the frequency domain output actually includes both positive and negative frequency components. When time domain samples from one signal source (one transducer) are fed into an FFT, the samples are typically placed into the direct part of the input and the quadrature part of the input is arbitrarily set to zero. For this situation, the FFT will produce a spectrum in which the negative frequency half of the spectrum is an exact mirror image of the positive frequency half. This is the usual case, and since the negative frequencies contain only redundant information, they are discarded.

If we examine the direct and quadrature complex number axes (Figure 3), we notice that their relationship is the

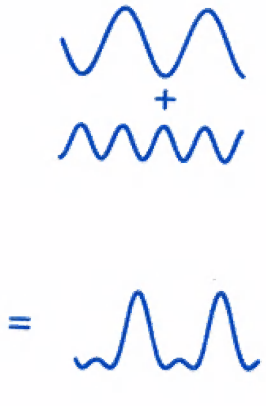


Figure 1
Any real waveform can be produced by adding sine waves together.

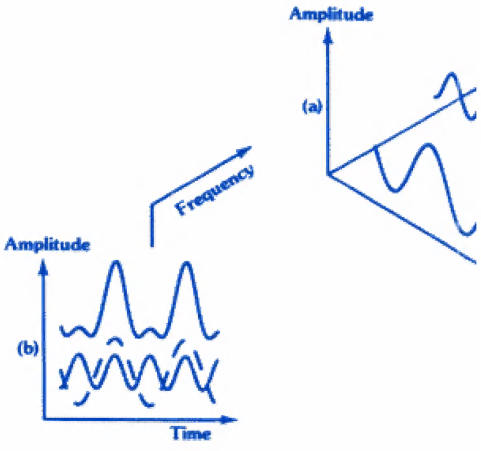


Figure
The relationship between the tir

a) Three-dimensional coordinates showing time, frequency and amplitude.

b) T

us Spectrum

Data Manager® 2 Software

same as XY vibration transducers. What would happen if we simultaneously sample the X and Y transducers and put the X probe samples into the direct part and the Y probe samples into the quadrature part of the FFT input? For this situation, the positive and negative frequency halves of the FFT output are not mirror images; the negative frequency half of the FFT output contains additional information.

Plus and Minus Spectrum Enhancement

We call this new technical advancement, Plus and Minus Spectrum Enhancement (Figure 4). Plus and Minus Spectrum Enhancement, which will be included in Transient Data Manager®2 Software, gives you more information than what is currently available in a standard Spectrum plot. Figure 4 shows how forward and reverse circular, elliptical and heavily preloaded Orbits would be displayed using Orbit/Timebase, Plus and Minus Spectrum, and Standard Spectrum plots.

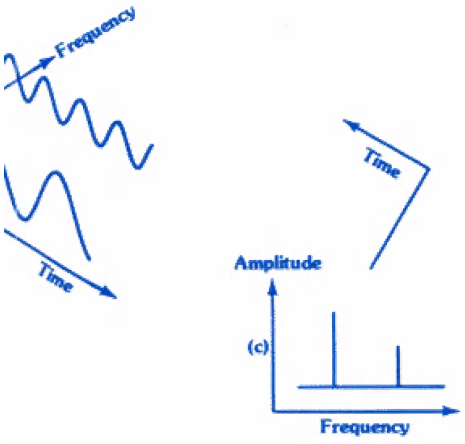
There are four main reasons for buying Plus and Minus Spectrum Software versus using your standard spectrum software.

- The degree of ellipticity, associated with preload and other machine conditions, normal and abnormal, can be determined.
- The precessional direction of all of the the vibration components can be determined.
- For computer orbits with several nonsynchronous components, the precessional direction for any component can be easily determined. This can be a significant augmentation of standard Orbit/Timebase techniques.
- Precessional directions obtained by other means, such as Orbit/Timebase or a Digital Vector Filter, can be verified to provide additional information.

For more information on Orbit/Timebase plots, refer to "Misalignment and Shaft Crack-Related Phase Relationships for 1X and 2X Vibration Components of Rotor Responses" by Dr. Agnes Muszynska, September 1989 Orbit, pages 4-8.

For single transducers, Timebase plots and positive frequency Spectrum plots still correspond to each other and provide the same information.

While Orbit/Timebase plots are vitally important to machinery malfunction diagnostics, the Plus and Minus Spectrum plot provides a valuable additional tool to help see the whole picture. For more information, contact your nearest Bently Nevada sales representative.►



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e time and frequency domains.

b) Time domain view c) Frequency domain view

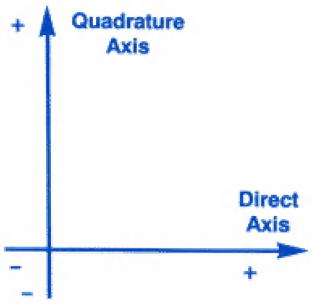
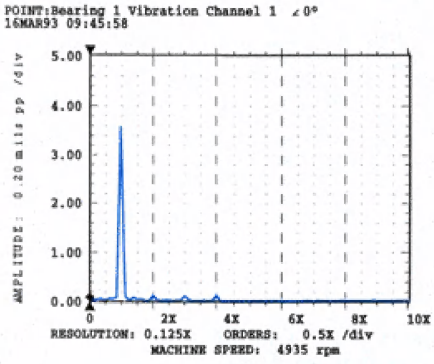
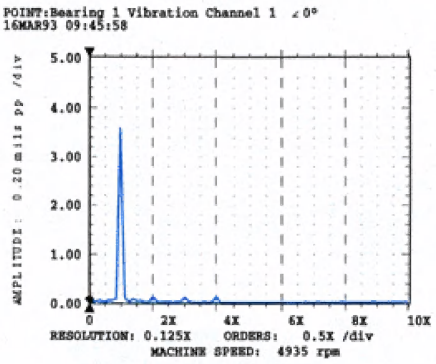


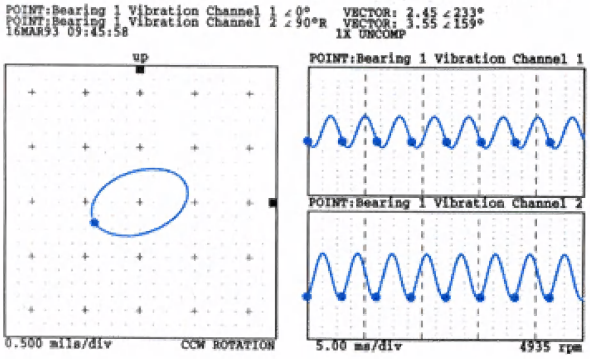
Figure 3
Complex number axes



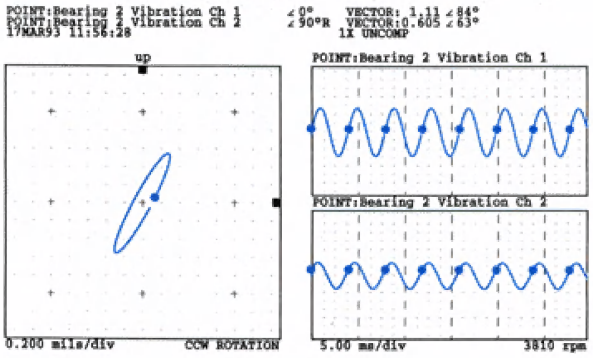
Spectrum



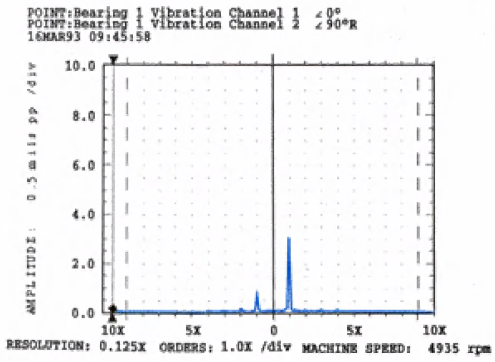
Spectrum



Orbit/Timebase



Orbit/Timebase



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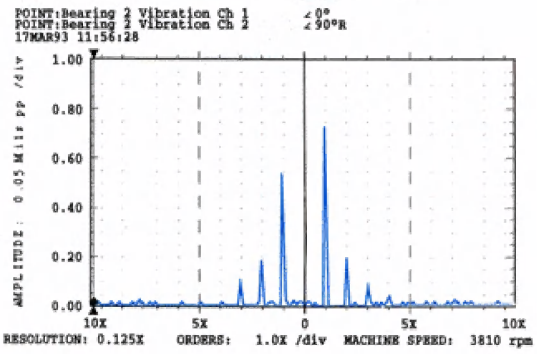
Plus and Minus Spectrum

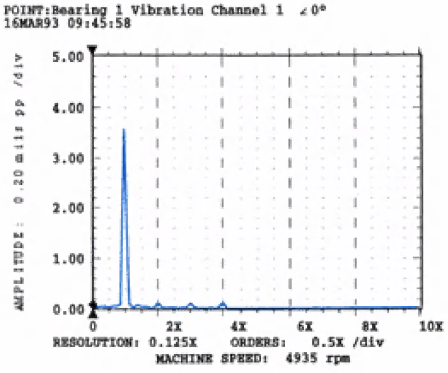


Enhanced
Plus and Minus Spectrum

Example 1

Example 2

Figure 4
Comparison between Orbit plots and plots available with Plus and Minus Spectrum Software



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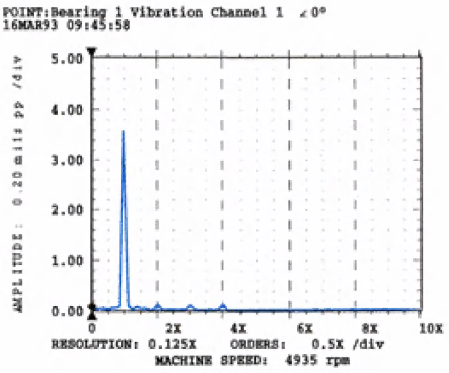

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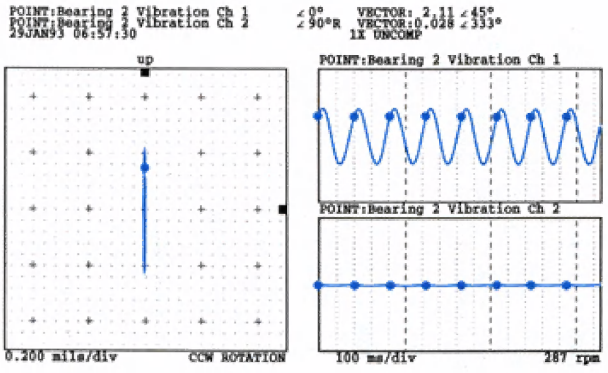
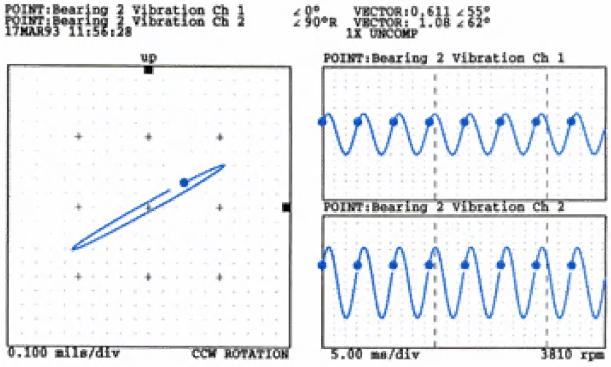
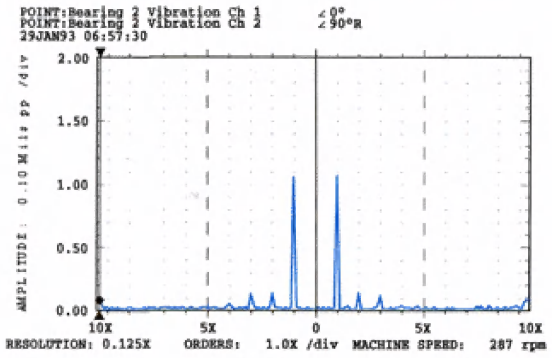


Orbit/Timebase



Orbit/Timebase



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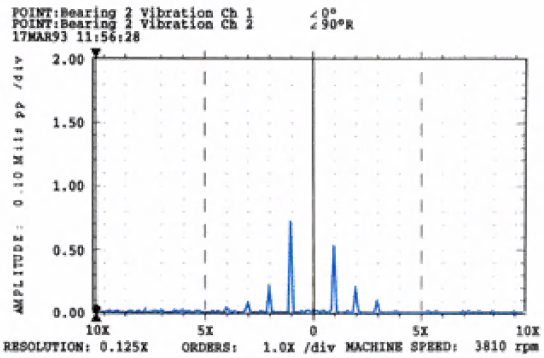
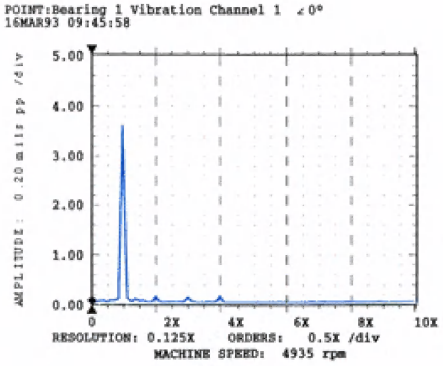


Enhanced
Plus and Minus Spectrum

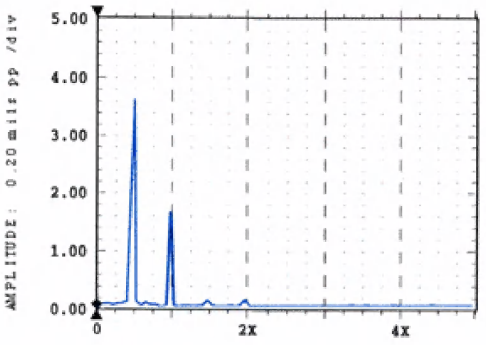
Example 3

Example 4

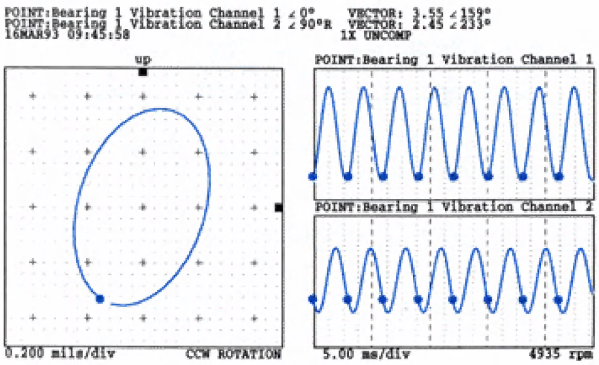
Figure 4
Comparison between Orbit plots and plots available with Plus and Minus Spectrum Software



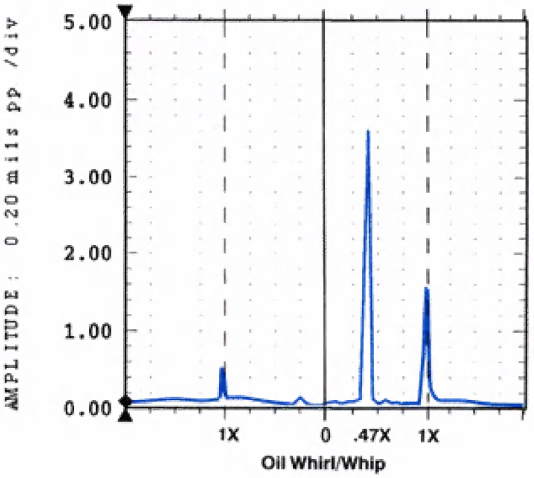
Spectrum



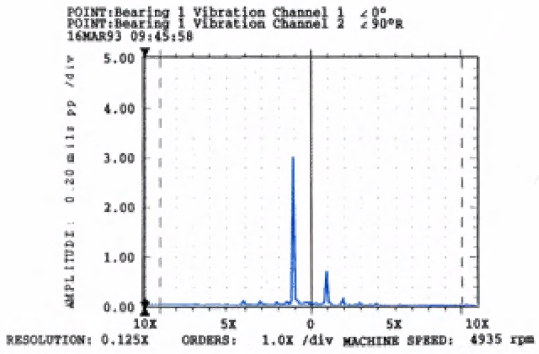
Spectrum



Orbit/Timebase



Oil Whirl/Whip



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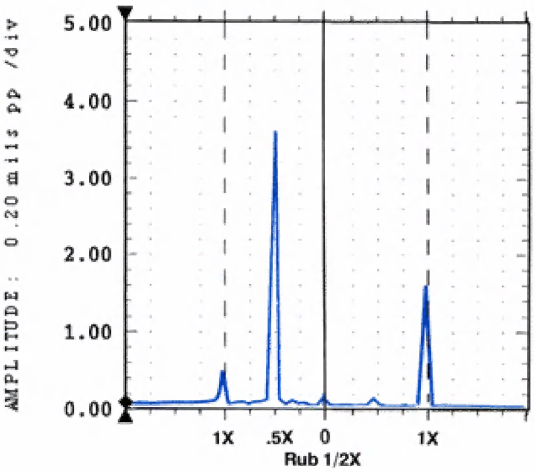
Plus and Minus Spectrum

Example 5



Enhanced
Plus and Minus Spectrum

Figure 4
Comparison between Orbit plots and plots available with Plus and Minus Spectrum Software

Figure 5
The advantages of using Plus and Minus Spectrum are apparent in the above examples of two very different machinery malfunctions.